HAMILTON (H.)

ARTIFICIAL INFANT ALIMENTATION.

BY

HUGH HAMILTON, M.D. (UNIV. OF PENNA.),
VISITING PHYSICIAN TO HARRISBURG (PA.) HOSPITAL, LATELY ANALYST TO THE PENNSYLVANIA STATE AGRICULTURAL SOCIETY.

EXTRACTED FROM THE TRANSACTIONS OF THE MEDICAL SOCIETY OF THE STATE OF PENNSYLVANIA FOR 1883.

PHILADELPHIA:
COLLINS, PRINTER, 705 JAYNE STREET.
1883.

ARTIFICIAL INFANT ALIMENTATION.

BY

HUGH HAMILTON, M.D. (UNIV. OF PENNA.),

VISITING PHYSICIAN TO HARRISBURG (PA.) HOSPITAL, LATELY ANALYST TO THE PENNSYLVANIA STATE AGRICULTURAL SOCIETY.

EXTRACTED FROM THE TRANSACTIONS OF THE MEDICAL SOCIETY OF THE STATE OF PENNSYLVANIA FOR 1883.

PHILADELPHIA:
COLLINS, PRINTER, 705 JAYNE STREET.
1883.

ARTIFICIAL INFANT ALIMENTATION.

THE inattention artificial infant feeding receives, and the valueless foods for sale, have suggested a scientific basis for such diet.

The explosive cry of the newly-born, the heaving trunk, the flattened nostril, prehensile upper lip and pouting lower one, form a most complete mechanism for the hydro-pneumatic problem of primitive existence through which the infant must pass.

The remarkable changes in the circulatory apparatus, the new function of respiration, and the assumption of assimilation by the digestive tract are subjects that, contemplated in detail, afford a fertile field for investigation.

The processes in the alimentary canal form the main points in our thesis, namely, Artificial Infant Alimentation, directing our thoughts to the development of these functions in infancy, the progressive natural diet offered for its nourishment, and the artificial aliment best adapted to the essential conditions of natal life.

The saliva being excreted slowly, of an alkaline reaction, its diastasic power is therefore limited.[1]

TABLE I.—*Excretion of Infant Saliva.*[2]

Age.	Time.	Amount.
21 days.	30 minutes.	15 grains.
56 "	2 "	15 "

TABLE II.—*Conversion of Starch to Sugar by Adult Saliva. Equal amounts.*[3]

Source of starches.	Time.
Potatoe	2 to 4 hours.
Pea	1 " 2 "
Wheat	$\frac{1}{2}$ " 1 hour.
Barley	10 " 15 minutes.
Oat	5 " 7 "
Rye	3 " 6 "
Corn	2 " 3 "

[1] A. Jacobi, M.D., Med. News (Phila.), xl. 173. See article by J. M. Keating, M.D., Boston Med. and Surg. Jour., cix. p. 31.

[2] Ibid. [3] Ibid.

Recent experiments with adult saliva show that its immediate convertive action upon starches does not cease at once in presence of dilute muriatic acid and the gastric juices.[1] The stomach juices are but partially excreted in infants, only those able to break albumins into readily assimilated forms.

TABLE III.—*Infant Assimilation, as shown by the proportion of blood-corpuscles in infants aged* 15 *to* 20 *days.*[2]

No. meal.	Time.		Corpuscles. White.	Corpuscles. Red.
1	First	Before meal	1	150
		½ hour after meal	1	155
		3 hours after "	1	145
2	Second	½ hour " "	1	100
		3 hours " "	1	142
3	Third.	½ hour " "	1	92
		3 hours " "	1	158

Tables III. and IV. illustrate the rapidity of assimilation, and the equally energetic demands of the vigorous vitality of a babe upon its blood stream.

TABLE IV.—*Proportion of Blood-corpuscles in Infants* 2½ *to* 3 *hours after meals.*[3]

Age in days.		Milk diet. Mother's. Human red corpuscles.	Milk diet. Cow's. Human red corpuscles.
½ to 3	To one white corpuscle.	135	122
4 " 7		157	135
8 " 14		165	140
15 " 30		173	145
31 " 60		180	153
61 " 90		185	160
91 " 120		191	172
120 " 150		210	180

The liver is slow to assume its functions, as illustrated by the icterus of early babyhood, and that bile is not excreted quickly is known by the constipation then frequent. At the age of four or five months the pancreas begin to secrete trypsin.[4]

[1] On Diastatic Action of Saliva, R. H. Crittenden and W. L. Griswold, Amer. Chem. Journ., Balt., iii. 305.

[2] Amer. Journ. Obstet. (N. Y.), Oct. 1882. Demé.

[3] Boston Med. and Surgical Journ., 1883, cviii. pp. 121–145.

[4] Pfluger's Archives, xxx. p. 295. Alex. Herzen, "Ueber den Einfluss des Miltz auf die Bilding des Trypsins (in dogs).

The bowel juices are alkaline if normal. When teething begins, the liver, pancreas, and spleen are sufficiently swollen to draw attention to the abdomen, the bile is then rapidly secreted, causing numerous healthful evacautions, to the relief of the now plethoric sensorium.

The colostrum is at once an excretion and secretion of utility. Its excretory cells irritate the stomach to peristaltic action, compelling the rectum to expel the meconium.

Fig. A, showing the ganglionic nervous system of the *pupa* of the CORYDALIS CORNUTUS (Leidy and Haldeman, *Proc. Acad. Nat. Sci.*, Philada., 1848), illustrates the simple forms in which reflex action is seen by the enlarged caudal ganglion, analogous to the sympathetic action between the human stomach and rectum.

The quantity of *fats* and sugar in colostrum is immediately absorbed, supplying the necessary hydro-carbon for the rapidly living and growing organism, and its albuminous fluid contains an albuminoid especially to assist primary digestion.

Fig. A.

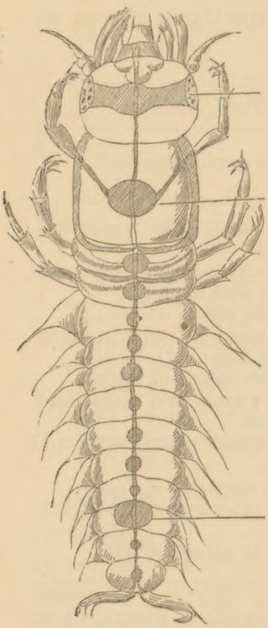

Fig. 1. COLOSTRUM.

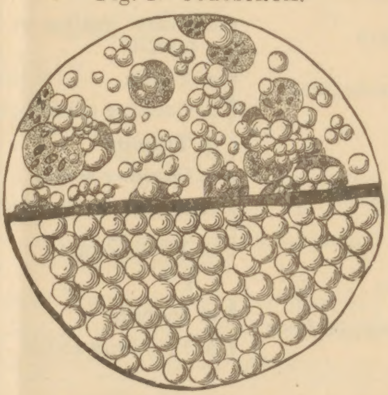

Fig 2. MILK.
Milk and colostrum, microscopically.

TABLE V.—*Human Milk and Colostrum.*[1]

Elements.	Colostrum. Fig. 1.	Milk. Fig. 2.
Casein	4 per cent.	3.43
Fat	7 "	4.54
Sugar	5 "	2.53
Ash	Less than milk.	.23
Water		88.36

[1] Vogel, Diseases of Children, N.Y., 1864.

*

TABLE VI.—*Human Milk Analyses.*[1]

From birth.	Fat.	Casein.	Sugar.	Ash.
1½ days	4.31	4.10	6.05	.53
9 "	4.07	3.02	5.78	.68
16 "	4.05	3.15	5.67	.69
23 "	3.98	3.11	5.80	.68
Right breast . . .	4.02	3.35	5.78	.60
Left breast . . .	2.67	3.29	5.54	.60

Human milk has been analyzed into casein, fatty matters, and sugar, like the product of the cow, but the bovine curd is of a much more permanent character. The reason was until recently undiscovered.

Meissner's classical researches upon digestive products, divided them into a series of *a*, *b*, and *c* peptones, respectively known as syntonin *para*-peptone and *dys*-peptone.

TABLE VII.—*Digestive Juices and their Ferments.*

Digestive juices.	Ferments contained in them.	Action on food materials.
Saliva . .	Salivary diastase or ptyalin . .	Changes starch into sugar and dextrine.
Gastric juice .	*a.* Pepsin . .	Changes albuminoids into peptones in acid medium.
	b. Curdling action .	Curdles the casein of milk.
Pancreatic juice	*a.* Trypsin . .	Changes proteids into peptone in alkaline and neutral media.
	b. Curdling action .	Curdles the casein of milk.
	c. Pancreatic diastase	Changes starch into sugar and dextrine.
	d. Emulsive act .	Emulsifies and partially saponifies fats.
Bile	?	Assists in emulsifying fats.
Intestinal juice .	*a.* Invertin . .	Changes cane-sugar into invert-sugar.
	b. ? Curdling action .	Curdles the casein of milk.

"An examination of the table shows that starch is attacked at two points—in the mouth and in the duodenum—by two ferments, salivary and pancreatic diastase, which are substantially identical. Albuminous matters are also attacked at two points—in the stomach and in the small intestine—but here the two ferments, pepsin and trypsin, are certainly not identical. The ferment, of which the only known characteristic is to curdle milk, is found in the stomach and in the pancreas—and I think also in the small intestine. The

[1] H. A. Mott, Ph.D., Amer. Chemist, vi. p. 367.

bile is known not only to possess the physical property of emulsifying and promoting the absorption of fatty matters, but other duties not clearly defined. The secretion which transforms cane-sugar, strange to say, is not encountered until the food reaches the small intestine."—ROBERTS.

In 1875, Schutzenberger, by a series of experiments, divided albumin into certain approximates. Albumin, when treated with dilute sulphuric acid, gave a gelatinous precipitate, slightly yellow, of weak acid reaction, and insoluble in water, alcohol, or ether, of the empirical formula $C_{24}H_{42}N_6O_{12} + H_2O$, named *hemi-protein.*

In the filtrate there was found an amorphous material of a very weak acid reaction, having the formula $C_{24}H_{40}N_6O_{10}$, designated hemi-albumin. The filtrate from hemi-albumin vigorously reduced Fehling's solution.[1]

Kuhne, in 1876, presented a scheme upon the digestion of albumin.

TABLE VIII.

Albumin.

	Anti-albumose.	Hemi-albumose.	
Anti-peptone.	Anti-peptone.	Hemi-peptone.	Hemi-peptone.
		Leucin tyrosin, etc., by action of trypsin.	Leucin tyrosin, etc.

TABLE IX.

Albumin.

Anti-group.	Hemi-group.
Anti-albumid (Hemi-protein).	
Anti-albumat (Para-peptone).	
Anti-albumose (Syntonin).	Hemi-albumose (A. peptone).
Anti-peptone.	Hemi-peptone.[2]

Anti-*albumid* (the hemi-*protein* of Schutzenberger) is insoluble in gastric juice, but soluble in solution of soda, and easily digested by trypsin. Anti-*albumat* (is the *para*-peptone of Meissner) is an abnormal result of digestion, due to insufficient pepsin; it is, however, soluble in gastric juice, but not absorbable until in contact with trypsin.

Anti-*albuminose* (or syntonin), is unaltered by stomach juices or trypsin, in short, it is the true anti-peptone; when these several albumins arrive at that stage, they are readily assimilated.

[1] Bulletin de la Société Chimique de Paris, 1875–6; also, Amer. Chem. Jour., vol. ii. p. 207.

[2] Verhandl. Naturhist. Med. Verins, Heidel. 1876; also, Amer. Chem. Jour., vol. ii. p. 211.

Hemi-*albumose* (Schutzenberger's hemi-albumin) is with difficulty soluble in cold, easily in hot water, in dilute alkalies, also in pepsin; through trypsin readily changed to hemi-*peptone*, when it separates into leucin and tyrosin, etc. Hence, it is observable that albuminous matter is parted by gastric juice into two groups, allowing of early and late digestion.

The *anti*-group is slowly absorbed, while the *hemi*-group is readily broken into further approximates.

Dr. T. Schmidt, in his inaugural dissertation, Moscow, 1882, thinks the amount of hemi-albumose in specimens of human and cow's milk constitutes the main difference between them.[1]

His experiments show where a sample of neutral cow's milk has five times its volume of two-per cent. solution of hemi-albumose added to it, that rennet extract does not coagulate it for at least twenty-four hours; should the reaction of the milk be acid, the mixture gives a flocculent precipitate, with no tendency to agglutinate or shrink the serum, and remains milky as in human milk when treated with rennet without hemi-albumose.[2]

TABLE X.—*Hemi-albumose in Human and Cow's Milk, with an Artificial Milk on that basis.*

Milk proteids.	Human.		Cow's	
	Per cent. proteids to whole milk.	Per cent. proteids to themselves.	Per cent. proteids to whole milk. X	Per cent. proteids to themselves. Z
Casein	.6573	49.8	3.1666	87.3
Albumin . . .	.3382	25.7	.2970	8.2
Hemi-albumose . .	.3224	24.5	.1672	4.5
Total proteids . .	1.3179	100		100

	Theory requires.[3] Taking cow's milk as a basis.		Artificial human milk.	
	Per cent. proteids to whole milk. 2X	Per cent. proteids only. 2Z	Per cent. proteids to whole milk. 3X	Per cent. proteids only. 3Z
Casein	Constant.	Constant.	3.1666	87.3
Albumin . . .	+1.1806	36.8	1.4776	45.0
Hemi-albumose .	+1.3707	38.4	1.5379	42.9

[1] N. Y. Med. Abstract, vol. iii. p. 76. [2] Op. cit.

[3] By the usual rules of proportion, using casein as a constant, add respectively columns X and 2X together; give the proportions which cow's milk should be to the constituents of human milk.

Hemi-albumose has the quality of being soluble, in an alkaline liquid at 55° C. (131° F.), charged with carbonic acid gas.

The chemistry of albuminous digestion leads us to see the reason that human milk is so admirably adapted to the little body dependent upon it.

If from imperfect female development the mother is unable to nourish her offspring, the acute disease causes, or its sad results deprive the babe of natural nutriment, then intelligent medical advice is of vital moment—what to recommend; what to avoid.

Dr. Hiram Corson,[1] in a paper read in 1870, at Saint Paul, Minn., was in favor of undiluted cow's milk for infants.

To physicians, not in cities, where a certain fat percentage may be relied upon in the milks, from recent chemical information, the task is comparatively easy. Respecting the milk from one cow, my friend, Prof. Sharpless, of Boston, an analyst, in an exhaustive paper before the American Academy of Arts and Sciences, says:—[2]

"A uniform diet for a child will be *much* better secured by mixing the milk of a number of healthy cows than when it is attempted by trying that of a single one. Since, as we see (Prof. Sharpless gave the details and results of 2209 analyses from 10 countries by 20 different analysts), and found the milk of any one cow varies very considerably."

In the following table (XI.) are comparisons of 2209 cows' milk and 129 human milk analyses, the variations of different milkings and teats of the cow. (See Table XII.)

TABLE XI.—*Average of Cows' and Human Milk Analyses.*

	COWS' MILKS. 16 different analysts, 2209 analyses, 10 different countries.[3]	HUMAN MILK. 4 different analysts, 129 analyses, white and black, American and European.[4]
Casein	4.14	4.78
Fat	3.87	3.31
Sugar	4.62	4.79
Ash	.63	.32

N. B.—Many of these analyses were made some time ago, before acquaintance with more precise information and methods.

[1] Pamphlets Medical, vol. iii. No. 11.

[2] Proc. Amer. Acad. Arts and Sci., vol. vii. pp. 49–98.

[3] Sharpless, Proc. Amer. Acad. Arts and Sci., vol. vii. 49–98.

[4] Mott, Amer. Chem., vi. 367.

TABLE XII.—*Differences in the Same Cow's Milk.*[1]

Runs.	Fat.	Casein.	Sugar.	Ash.
First	1.84	3.01	4.49	.54
Second	3.03	4.25	4.80	.58
Third	4.03	3.90	4.50	.54
Teats.				
Right forward . .	3.32	3.53	4.90	.59
Left forward . . .	3 00	3.42	5.00	.57
Right rear	2.73	3.61	4.72	.61
Left rear . . .	2.13	3.48	4.88	.64

A leader in one of the late London medical journals[2] remarks upon the discrepancy of human milk analyses, and how misleading they are when only the proportions between casein and albumen are thought sufficient to account for the unsatisfactory behavior of the milk of different animals.

TABLE XIII.—*Relation of Casein to Infant Mortality.*

	Human milk.	Asses' milk.	Goats' milk.	Cows' milk.
Casein to 100 parts of albumen .	122	155	173	237
Number of infants used . .	...	38	42	6
Dead resulting	...	10	34	5

	Asses' milk.	Goats' milk.	Cows' milk.
Percentage of living infants . . .	74	20	17
" dead " . . .	26+	80+	83

The problem is yet exceedingly difficult what to suggest as a suitable diet for infants where no natural fresh animal product is to be had.

If the variations in the product of milch cows is notorious (refer to Table XII.), what must it be in a sensitive animal like the human female?

The statistics of mortality in infant institutions is a pointed comment upon our progress in a matter of such vital importance to our national existence. See Table XIII.

Dr. A. V. Meigs,[3] of Philadelphia, after a careful survey of that field, advises condensed milk diluted with six volumes of water, while the proportion of fats are to be made up with the addition of cream. He states in a foot-note that the cream contained but 12

[1] Op. cit., see Table XI.

[2] London Med. Times and Gazette, vol. i. (1883) p. 385, whole No. 1710.

[3] Med. News, Phila., xli. p. 505.

per cent. of fats. Then *where* will he get fats to add to the condensed milk? as good new milk should have 9 to 13 per cent. of cream in it.

Dr. Keating,[1] in an able lecture, depicts his difficulties in the effort to substitute *gluten*, a vegetable diastase, for the animal diastase, *saliva.*

Just here is a matter demanding attention, namely, that *vegetable* albumin, gluten, and maltose are not animal albumin, saliva, or lactose, though like unto them; exceedingly important in their relation to assimilation by an organism.

TABLE XIV.—*Chemical-Isometrism.*

Cellulose. Starch. Dextrin. All have formula $C_{12}\ H_{20}\ O_{10}$	Cane sugar (sacchrose). Milk sugar (lactose). Malt sugar (maltose). All have formula $C_{12}\ H_{22}\ O_{11}$

Possibly better illustrated by the disposition of the letters *T*, *A*, and *R*, when being transposed to read *TAR*, *RAT*, and *ART*, words of very dissimilar significance.

If nothing but these artificial vegetable foods are procurable a child *may exist* until able to take substantial diet.

Dr. E. Cutter[2] examined many artificial foods MICROSCOPICALLY, resulting in the following classification:—

TABLE XV.—*Artificial Infants' Foods.*

1. Containing *more* gluten than flour:—

Franklin Mills Entire Flour, Hawley's Liebig Food, Arlington Wheat Meal,	Mead's Wheat Flour, Baby Sop.

2. Equal to wheat flour, which contains gluten 3.50, starch 63.64:—

Gluten N. Y. Health Food Co., Savory & Moore Food,	Horlick's Food.

3. *Less* gluten than flour:—

Ridge's, Mellin's, Gluten Flour, Anglo-Swiss,	Victor's Baby Food, Geiber's, Mother's Milk Substitute.

4. No gluten:—

Keasby & Mattieson, Imperial Granum, Crosby's Brain and Nerve, Blanchard's Glutena, Duke's Glutena, Blair's Food,	Redmon's Ceraline, Farwell's Glutena Flour, Taylor Bro., arrowroot mainly, Potatoes starch, Hubbell's Prepared Wheat, N. Y. Food Co.'s Flours.

[1] Phila. Med. Times, vol. xii. p. 33.

[2] Amer. Med. Weekly, January 7, 1882.

Table XVI.

Prof. A. R. Leeds[1] also examined them CHEMICALLY.

Foods.	Water.	Fat.	Grape sugar.	Cane sugar.	Starch.	Gums, etc.	Albuminoids. C H O N S P Fe, etc.	Ash.
Theoretical Food . .	81	3	..	11	..	..	4	1
FARINACEOUS FOODS—								
Hubbell's	7.78	.41	7.56	4.87	67.60	..	10.13	1
Blair's	9.85	1.56	1.75	1.71	64.80	2.94	7.16	Unde.
Imperial Granum .	5.94	1.01	..	..	78.93	.50	10.51	do.
Ridge's	9.93	.63	2.40	2.20	77.96	..	9.24	do.
Victor's Baby . . .	7.49	1.62	.62	19.92	63.45	..	8.87	.96
Farwell & Rhine . .	12.67	.84	2.23	1.42	68.36	.51	10.39	1.09
N. Y. Health Food Co.	11.90	..	..	..	49.53	..	23.18	Unde.
MILK FOODS—								
Gerber's	6.78	2.21	6.06	30.50	38.48	..	9.56	Unde.
Anglo-Swiss . . .	6.54	2.72	23.29	21.40	34.55	..	10.26	1.20
LIEBIG'S FOODS—								
Savory & Moore's. .	8.34	.40	20.41	9.08	36.36	.44	9.63	
[2]Mellin's	5.00	.15	44.69	3.51	None.	..	None.	1.89
Horlick's	3.39	.08	34.90	12.45	do.	..	6.71	1.28
Hawley's	6.60	.61	40.57	3.44	10.97	..	5.38	1.50
Keasby & Mattieson	27.95	None.	36.75	7.58	None.	..	None.	.93
Baby Sop	11.48	.62	2.44	2.48	51.95	5.24	7.92	1.59

Upon these microscopical or chemical bases respecting infant foods, one of two opinions forces itself upon our minds: 1st. That Liebig's theory of the necessary changes of starches to sugar for assimilation is wrong; or, 2d. That an *unknown* factor exists, as the variable success of the profession, by the use of these patent foods, seems to indicate. The want of this information brings to the household sorrow and to the nation loss.

We do, however, reach this conclusion, that: The use of mixed healthy cow's milk, rendered alkaline by bicarbonate of soda (baking soda, NOT *powder*), with the addition of a tablespoonful or two, as the child is older, of good cream to half pint of milk, and then heated to 55° C. (121° F.), and afterwards sweetened by a strong freshly prepared syrup of lactose or milk sugar, forms the most admirable artificial infant aliment now known (see Table X.).

[1] See New York Med. Journ., xxxvii. p. 149, April 28, 1883.

[2] Since Prof. Leeds's paper has appeared in the N. Y. Med. Jour., advance sheets of the Sixth Annual Report of Board of Health of N. J., in which he says Mellin's food contains between 4 and 5 per cent. of albuminoids. (See pp. 204 and 206 of that paper.)